LIGHT AND MATTER

A NEW CLASSICAL THEORY OF LIGHT AND MATTER BASED ON THE MAXWELL EQUATIONS AND THE SPECIAL RELATIVITY THEORY WITH CRITICISMS OF THE EXISTING THEORIES

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PREFACE TO THE FIRST EDITION

My paper, *A New Classical Theory of the Photon and the Electron* was published in Vol. XII, No. 6 of the PROCEEDINGS OF THE NATIONAL INSTITUTE OF SCIENCES OF INDIA in August, 1946; a short summary had been published in SCIENCE AND CULTURE of January, 1946. Though prints were widely distributed among the leading physicists, the learned societies and the scientific journals of India, Europe and America with an open invitation for comment and specific criticism, the response was disappointing. A few courteous acknowledgments were received but no criticism, constructive or destructive.

In the present booklet, the objections to the current theories have been explained in greater detail, supported by extensive quotations from well-known authorities, and the main thesis itself has been expounded more fully. It has been my endeavour to present the case against the existing theories and formulate the new theories in as readable a form as possible. The mathematics is fairly simple and will, it is hoped, be intelligible even to those physicists whose mathematical equipment may not be high.

It may be stated here that the thesis has no conflict with Quantum Mechanics regarded from a statistical point of view, though there is a certain amount of divergence. Even if the present theory be accepted, Quantum Mechanics will not have to be scrapped, but will have to be re-written from a new standpoint.

I shall feel grateful for any comment or criticism which may be offered. Any expression of approval or suggestion for improvement will be doubly welcome. In any case, it behoves the Quantum physicists to meet the criticisms levelled against them. Truth is not served by ignoring criticism. I trust, however, that argument of the type "Fifty thousand Frenchmen cannot be wrong" will not be brought forward, either explicitly or by implication.

12, BALLYGUNGE CIRCULAR ROAD,
CALCUTTA, *15th June, 1947.*

B. M. SEN

PREFACE TO THE SECOND EDITION

THE reception to the booklet has not been enthusiastic—not that there was any fault or defect found in the main arguments. Requests for comments and criticisms to physicists and scientific periodicals excited no response. But mere shaking of the head however wise is not criticism. Only one defect was pointed by the Editor of a well known journal, *viz.*, the assumption of the invariance of the electromagnetic vector under Lorentz transformation, while the invariance of the Maxwell equations was the proposition proved. But when the lacuna was filled in a subsequent paper, the journal refused its publication as unsuitable! The fact is that those who would be judges are themselves deeply committed to the current theory. Naturally they are loath to accept the challenge and enter into arguments. One sympathetic physicist offered the consolation that Mendel's work was recognised fifty years after his death!

The only gesture of encouragement which is gratefully acknowledged came from a mathematician, Prof. Birkhoff who as Chairman of the International Congress of Mathematicians at Harvard in 1950, recommended my name for a special invitation. But the invitations had gone out and there was no vacant place. I received also invitations from the International Congress of Mathematicians at Amsterdam in 1954, and from the Seminars for Theoretical Physics in Aachen, Heidelberg, Cambridge and the University College, London. I thank the authorities for the courtesy.

In the circumstances, all that I can do is to embody the results obtained and leave the matter to the judgment of posterity. My three objections to the Einstein principle $W = h\nu$ which is the basis of modern physics are still unanswered. They are:

(i) a divisible beam with an indivisible quantum of energy is a contradiction in terms, (ii) the theory that light behaves as a particle or a wave just to suit experimental needs, introduces the supernatural in the domain of natural philosophy, (iii) the existence of the continuous spectrum implies infinite radiated energy. These are logical defects and until they are answered, modern Physics can only be regarded as emperical, all its successes notwithstanding. The supposed verification of any theory is not always a reliable indication of its truth as has been proved in the case of Dirac's prophecy of the positron and Yukawa's of the meson. The scope of modern experimental physics is so vast that it is a very complicated jigsaw puzzle to formulate a theory to fit all known facts.

In this edition the booklet has been revised and in places, the arguments amended. Once again I invite comments and criticisms.

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7th May, 1958

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Chapter I

THEORIES OF LIGHT—HISTORICAL AND CRITICAL

1. The various theories of light—the elastic solid theory of Fresnel and Young, the electromagnetic theory of Maxwell, the quantum theory of Planck and Einstein and the wave theory of Schrödinger, Heisenberg and Dirac—have one characteristic in common. They all emphasise their successes and pass lightly over their difficulties. Like the proverbial curate's egg, they are all good in parts. To get a clear concept of their failures and difficulties it is necessary to recount them with special emphasis. This is a necessary preliminary before the formulation of the successful theory.

When a theory does not explain, or if it runs counter to, facts of experiment, the usual practice in the scientific world is, or at least ought to be, to hold the theory in suspense until such difficulties are cleared. When any theory contradicts a generally accepted principle, the only logical procedure is to give up either the theory or the principle. But in present day physics, all the theories are accepted, each reigning supreme in its own limited sphere though contradicting the others in fundamentals. All efforts at co-ordination have had no marked success. The correspondence principle, seeking to bridge the gulf between the classical theory and the quantum theory,

accepting the former when convenient and rejecting it in other cases, without reconciling the fundamental concepts, has added to the confusion of the entire position. Modern physics has very conveniently forgotten the fundamental principle of logic that no theory may be half right and half wrong. There are no tight compartments in the brain for different physical theories.

2. As is well known, the elastic solid theory is eminently successful in the region of Physical Optics, though the fundamental assumption about the nature of production of light waves, *viz.*, vibration of electrons in an elastic solid medium dragging the jelly-like material after themselves, has long been given up. The facts of Geometrical Optics, reflection and refraction, are explained by any wave theory and those of Physical Optics—polarisation, interference and diffraction—are all explained simply and apparently conclusively by the elastic solid theory. It put itself into a practically impregnable position for those times (the end of the eighteenth century) by discovering and explaining diffraction and thus overcoming Newton's objection that waves must be capable of bending round straight edges, which apparently light waves cannot do.

But the theory fails abjectly when the energy of such waves is considered. For interference, it is essential that the same single beam must be divided into two components which are made to recombine after one of them has been retarded by half a wave-length. It is a matter of common experience that two separate beams cannot be made to interfere. But the energy of a beam, according to the

elastic solid theory, is proportional to the square of the amplitude of vibration. The amplitude of the original beam, on the other hand, is equal to the sum of the amplitudes of the component beams.*

This means a violent clash with the principle of Conservation of Energy, with no means of escape. Unless physicists were prepared to give up the Principle of Energy, the only logical course would have been to regard the theory at least with some reservation. But curiously enough, this big difficulty is simply passed over and as far as our knowledge goes, no mention is ever made of it in any of the current text-books on Physical Optics. It is inconceivable that such an elementary and fundamental difficulty could have escaped the notice of physicists over so many years.

3. Maxwell's electromagnetic theory records a great achievement in establishing connection between several branches of Physics, light, electricity and magnetism hitherto regarded as absolutely independent of one another. Its main contribution is to specify the nature of the light waves while accepting in a vague way the explanations of

* A physicist friend has pointed out that the amplitude of the original beam is equal to the vector sum of the amplitudes of the component beams and that a difference of phase is introduced by reflection. We have considered here the amplitude at the instant of separation of the two beams before the reflection actually takes place. Also vector addition does not bar out scalar addition which is a special case. In any case, it is not worth while to examine the point more thoroughly, as the theory itself has been given up, except for college teaching.

[illegible] in a free medium

$$E = E_1 + E_2$$

[illegible] have

$$E^2 = E_1^2 + E_2^2.$$

[illegible] any exposition of the Maxwell theory.

[illegible] exp. $(ik_1 x \cos\theta_1 \ldots y \sin\theta_1 \ldots)$ [illegible] exp. $(ik_2 x \ldots \theta \ldots y \sin\theta)$ [illegible] exp. $(ik_3 x \ldots \theta_3 \ldots y \sin\theta)$ [illegible]

$$k_1 \sin\theta \ldots k \sin\theta \ldots k \ldots \theta_3$$

$$K_1V_1 = K_2V_2 = K_3V_3.$$

[illegible] deduced from practically any [illegible]

[illegible] dent anxiety that the equality should [illegible] II [illegible]

[illegible] Maxwell [illegible]

[illegible] has been deduced on the supposition that the [illegible] obscure.

[illegible] quanta in the incident beam.

[illegible] 1889.

5. But the Einstein [illegible] quite [illegible] the problem [illegible] that [illegible] same beam [illegible] split [illegible] two components [illegible] most [illegible] Quantum Mechanics [illegible] would [illegible] suspect that such a problem [illegible]. It [illegible] the following explanation.

Suppose we [illegible] of light [illegible] passed [illegible] other kind of [illegible] split up [illegible] components [illegible] partly [illegible]. We [illegible] what [illegible] the apparatus [illegible] present to us the difficulty of [illegible] the wave and corpuscular theories of light [illegible]. We [illegible] photon [illegible] partly [illegible] of the two components and which [illegible] beam is split. [illegible] definite state [illegible] single beam of light and may be associated with two or more beams of light [illegible] the components into which [illegible] beam has been split. (Dirac, p. 7.)

Such an argument [illegible] Dirac's [illegible] but it breaks down at the most superficial [illegible]. What happens when [illegible] component beams are widely separated [illegible]? The quantum of energy cannot be present [illegible] both [illegible] that the [illegible] of energy [illegible] of miles away from the path of the beam. We must [illegible]

[illegible] Obviously, no amount of sophistry can explain the divisibility of a beam as required by the phenomenon of interference and retain the indivisible quantum of energy as enunciated by Einstein.

[illegible]

p. 88)

[illegible]

[illegible] **Apparently physicists find nothing incongruous in the introduction of the supernatural in the domain of natural philosophy**

[illegible], but belong [illegible] without any trace of apology [illegible] belittling our shortcoming

[illegible]

[illegible]

[illegible] explained why radio waves of length 15 to 400 metres can [illegible]

[illegible] elementary conclusion of the Theory of Sets of Points that a continuous line of finite length—it is immaterial whether [illegible] must be infinite. Not even the store of energy of the sun [illegible] It seems that in their preoccupation with complex experiments physicists have lost sight of the dispersion of white light by a prism—an experiment familiar to every schoolboy.

[illegible]

[illegible]

[illegible] Quantum [illegible] assumption has long been discarded. In fact [illegible] two simple harmonic oscillations.

[illegible]

[illegible] contradict it.

[illegible] (Heitler, p. 113)

$$\Delta E \Delta t \approx h$$

[illegible]

the [illegible] the [illegible] for example [illegible] the [illegible] of the spectrum. It then [illegible] in all these [illegible] **Einstein's relation [illegible] must be regarded as an over-generalisation.**

11. Again Dirac defines his δ-function as follows

$$\delta(x) = 0 \text{ when } x \neq 0, \quad \int_{-\infty}^{\infty} \delta(x)\,dx = 1 \qquad \text{(Dirac, p. 72)}$$

This function plays [illegible] in Quantum Mechanics.

Taken literally the integral [illegible] of the independent variable when [illegible] more than [illegible] point. If we extend the definition by making $\delta(x)$ [illegible] when x does not lie between [illegible] and then make $\epsilon \to 0$, it is easily seen that $\delta(x)$ cannot exist. Let us suppose that the [illegible] integral of $\delta(x)$ is $f(x)$. Then

$$f(+\epsilon) - f(-\epsilon) = 1$$

If we make [illegible] of the [illegible] It cannot [illegible] possess a differential [illegible] the [illegible] δ-function [illegible] Dirac [illegible] that it is an improper function, but it has not [illegible] in Quantum Mechanics.

We have [illegible] a function defined as follows [illegible]

$$F(x) = \underset{\epsilon \to 0}{Lt} \frac{\epsilon}{\pi(x^2 + \epsilon^2)},$$

[illegible]

[illegible] which is not usually permissible.

[illegible] foundation.

[illegible] mathematicians.

[illegible]

If $\qquad e^a e^b \neq e^b e^a, \quad$ then $\quad a + b \neq b + a$

[illegible] therefore [illegible] in the sum of two dynamical variables. This would create [illegible] difficulties in manipulation [illegible] which further [illegible].

In [illegible] expression [illegible] it is usual to substitute [illegible] when [illegible] eye of the teacher.

[illegible] equation

$$H = [illegible]$$

of the motion of a free electron. We [illegible] surprising result

$$\dot{x} = [x, H] = -c\alpha_x.$$

[illegible] measurement of a component of the velocity of a free electron [illegible] field present.

Dirac has taken great pains to explain away this astonishing result. He asserts that the contradiction is not [illegible] since the theoretical velocity in the above conclusion is the velocity at one instant of time while observed velocities are always average velocities through appreciable time intervals.

[illegible]

part [illegible] H^{-1}

[illegible]

[illegible] Relativity theory is not to be given up.

Again, [illegible]

or, the velocity of the electron [illegible] exactly do they stand for ?

[illegible]

with the frequency of the corresponding jumps are

$$W_l - W_m = h\nu_{lm}$$
$$W_m - W_n = h\nu_{mn}.$$

[illegible]

[illegible] One simple example [illegible] values must be integers in order that the solutions of the wave equations [illegible] subsequently [illegible] previous work.

Chapter II

WHAT IS MATTER

[illegible]

[illegible]

concepts to the minimum number has been given up. [illegible]

[illegible] where experimentation is possible.

[illegible]

[illegible] Physics faces these problems.

[illegible]

[illegible] mathematical equations.

[illegible]

535 L

Sc 474

[illegible]

[illegible]

this particularly simple case.

[illegible]

[illegible] electron being at that point.

[illegible] per electron.

[illegible] of waves would [illegible] permanent structures. [illegible] identity as such.

[illegible]

different

[illegible] varies very slowly with x; so that the [illegible] [illegible]

$$U = (\sigma - \sigma')/(k - k')$$

or ultimately $U = d\sigma / dk$.

In terms of the wave length

$$U = \frac{d(kv)}{dk} = v - \lambda \frac{dv}{d\lambda}.$$

[illegible] velocity.

[illegible] the velocity of [illegible]

7. [illegible] 1927 [illegible]

[illegible] p. 357).—

"We define $\Psi(x,t)$ by the equation

$$\Psi(x,\,t) \equiv \int G(\sigma)e^{2\pi i(\sigma x-\nu t)}d\sigma,$$

[illegible] equation

$$\frac{\partial^2\Psi}{\partial x^2}+\frac{4\pi\mu i}{h}\frac{\partial\Psi}{\partial t}=0 \text{ if } \frac{\nu}{h}=\frac{\sigma^2}{2\mu}.$$

[illegible] to be zero. μ is the mass of the electron.)"

[illegible] motion.

"[illegible]

[illegible]

[illegible] fixed parameters which [illegible] integration σ." [illegible] form

$$\left(\frac{dv}{d\sigma}\right)_{\sigma_0} = [illegible]$$

[illegible] unending procession.

[illegible] (pp. 10-12):—

[illegible]

[illegible] manner. If the train is monochromatic and long enough to include many waves, it will travel with a fairly definite speed even in a dispersive medium. [illegible]

packet.

[illegible]

[illegible] are physicists [illegible] [illegible] (p. 31):—

To interpret the spatial extension (radius) usually attributed to electrons (on the basis of the electromagnetic theory of mass) Schrödinger [illegible] preferred to represent electrons by wave packets of finite dimensions. The latter point of view is, however, contradicted by the fact that wave packets do not preserve the same dimensions, but spread out in space as time goes on, whereas the dimensions of the particles they represent [illegible] constant.

"But [illegible] from this, the conception of particles as wave packets contradicts the facts of observation on the interference and diffraction of the corresponding rays [illegible] single electron, then the scattering of these rays at a [illegible] pattern similar to that which is observed in the case of homogeneous light waves. In fact, to explain this interference pattern by the wave theory we must assume that the incident [illegible] waves [illegible] a constant [illegible] the finite cross-section and divergence of the bundle of rays).

"Thus the representation of the individual electrons [illegible]

[illegible] displayed.

"Discontinuous elementary actions of light or material [illegible] structure—of this field.

[illegible]

[illegible] can have no physical import either.

[illegible]

[illegible]

[illegible] packet will cease to have any meaning.

[illegible] undulatory but wholly abstract nature.

[illegible]

may arise from on[illegible]ing to [illegible] happenings wh[illegible] on time dimensions into a s[illegible] number of dim[illegible]. If this represents a fair con[illegible]sus of opinion, physics is not very far from the con[illegible] of one school of Hindu philosophy that matt[illegible] illusion, being only a manifestation of the Supr[illegible] Consciousness.

Again, the probability of an event offers [illegible] due to the nature or character of the actors [illegible] the drama [illegible], even [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] **As far as any indication about the physical structure of the particle is concerned, the probability theory is mere empty verbiage. It attempts an answer to the query "where is matter" and not "what is matter".**

[illegible]

[illegible] on observation alone.

[illegible]

likely than any other [illegible]. A universal illustration of the doctrine is the spinning of a coin. In fact, the probability of heads and tails turning up in equal proportion [illegible] number of tosses is [illegible] [illegible] much more fundamental than many of the axioms hitherto accepted without a shadow of doubt.

Jeans says: "We can illustrate the concept by an analogous situation in a large-scale world. If we spin a half-penny, *nothing* [illegible] *far* (italics are ours) may be able to discover whether it will come down heads or [illegible] [illegible] will [illegible]."

[illegible] rigid body (if it is rigid) and any mathematician can predict the result of a toss provided the [illegible] conditions, the initial position, impulse, etc. [illegible]. The uncertain element is the lack of definite [illegible] and the difficulty of ascertaining them when a coin is tossed with the fingers. But certainly it is not beyond the human ingenuity to devise a machine which could spin a coin head up every time, if any one could be found to spend his energy on anything so futile!

A dissenter would reply that Jeans' contention would hold [illegible]

[illegible]

This clamours for an explanation.

[illegible]

order to understand."

CHAPTER III

A NEW THEORY OF LIGHT

[illegible] Maxwell [illegible] may be written as

$$\operatorname{curl} E + \frac{1}{c}\dot{H} = 0,$$

$$\operatorname{div} H = 0,$$

$$\operatorname{curl} H - \frac{1}{c}\dot{E} = 0,$$

$$\operatorname{div} E = 0, \qquad \dots \quad (1)$$

[illegible]

$$\nabla^2 F - \frac{1}{c^2}\frac{d^2 F}{dt^2} = 0, \qquad \dots \quad (2)$$

[illegible]

The general solution of equations (1, 2) in one dimension of space is given by

$$E_y = H_z = f(x-ct) \qquad \ldots \quad (4)$$

the other electric and magnetic components being zero. If this has to present the Doppler effect, f must also be [illegible] [illegible] we write

$$E_y = H_z = \phi(x-ct)\sin k(x-ct).$$

[illegible] [illegible] x-axis is

$$x=\beta(x'+vt'),\ y=y',\ z=z',\ t=\beta(t'+vx'/c^2),$$
$$\beta=(1-v^2/c^2)^{-\frac{1}{2}}.$$

We have then

$$x-ct=\beta(1-v/c)(x'-ct'). \qquad \ldots \quad (5)$$

[illegible] sin $k(x-ct)$ becomes sin $k'(x'-ct')$, where

$$k'=k\beta(1-v/c)=k\sqrt{(1-v/c)/(1+v/c)}.$$

Introducing the frequency $\nu=kc/2\pi$, we have

$$\nu'=\nu\sqrt{(1-v/c)/(1+v/c)}.$$

This is [illegible] Doppler effect.

It is well known [illegible] Lorentz that the Maxwell equations [illegible] provided we write

$$E_{x'}=E_x=0$$

$$E_{y'}=\beta(E_y-v/c\,H_z)=\beta(1-v/c)\ldots$$

$$\mathcal{E}_{z'} = \beta(E_z + v_x H_y) = 0$$
$$\mathcal{H}_{x'} = H_x = 0$$
$$\mathcal{H}_{y'} = \beta(H_y + v_x E_z) = 0$$
$$\mathcal{H}_{z'} = \beta(H_z \text{ [illegible]}$$

[illegible] actual electromagnetic [illegible]

$E_x, E_{y'}, E_{z'}, H_x, H_y, H_z$ [illegible]

[illegible]

The first [illegible]

[illegible] to 1 when $v = 0$.

We may then write

$$E_{y'} = \beta(1 - v/c)\psi(v/c)E_y$$
$$H_{z'} = \beta(1 - v/c)\psi(v/c)H_z \quad \ldots \quad (7)$$

[illegible] $v = 0$. We have then

$$E_y = \psi(v/c)E_{y'}, \quad H_z = \psi(v/c)H_{z'},$$

$E_{y'}$, $H_{z'}$ representing the electromagnetic vector [illegible] the same [illegible] since $E_{y'}$, $H_{z'}$ must reduce to E_y, H_z [illegible] relativity postulate [illegible]

[illegible]
factor for the present, we thus have

$$E_y = \phi(x-ct)$$

$$E_{y'} = \psi(v/c)E_y = \phi(x'-ct').$$

[illegible]
relative to O is

$$w = \frac{v+v'}{1+vv'/c^2}.$$

[illegible]
observer O''

$$E_{y''} = \psi(v/c)\psi(v'/c)\phi(x-ct)$$

$$= \psi(w/c)\phi(x-ct) \qquad \text{.. (9)}$$

as direct transformation.

[illegible]

[illegible]

$$[illegible] = \tanh(\theta + \theta')$$

[illegible]

positive or negative, integral or fractional

Again, $\frac{v}{c}$ [illegible]

or, $\frac{1 - v/c}{1 [illegible]} = e^{-2\theta}$ [illegible]

[illegible] β [illegible]

We have, therefore, $\chi(v/c) = a\theta$

or, $\psi(v/c) = e^{a\theta} = \{\beta(1 - v/c)\}^{n}$.

We get, therefore,

$$[illegible] = \{\beta [illegible]\} [illegible]$$

Also, $x - ct = \beta(1 - v/c)(x' - ct')$.

Eliminating $\beta(1 - v/c)$ we have

$$[illegible]$$

[illegible]

We [illegible] $\phi(x - ct) = A(x - ct)^{n}$

[illegible] $f = A(x - ct)^{n} \sin k(x - ct)$ [illegible]

[illegible] the same [illegible]

[illegible] only two [illegible] which [illegible] E [illegible] the other. The first [illegible] gives

$$E_y = H_z = A \sin k(x - ct)$$

this is the basis of the ordinary theory which has proved inadequate. The other [illegible] giving

$$E_y = H_z = A \sin k(x - ct)\,(x - ct) \quad \ldots (11)$$

which is taken as the basis of our theory. [illegible] multiple-valued.

The conclusion is, therefore, irresistible that if the Maxwell equations hold good as well as the special Relativity theory, a linear photon obeying Doppler's principle must have its electric and magnetic vectors perpendicular and in a plane perpendicular to the direction of propagation and in the form (11). There is no way of [illegible] this [illegible] unless we are [illegible] enough to accept the premises and deny the conclusion.

It is usual, when considering any solution of the Maxwell equations to introduce the conception of a wave front (see e.g. Frenkel pp. 15-16). This is a relic of Fresnel and Young's theory in which every point of the wave front was supposed to be a centre of disturbance and the wave front was supposed to move perpendicular to the ray. In the Maxwell theory the direction of propagation of the beam plays a fundamental part and the wave front is not only superfluous but misleading. If we take the Maxwell field $E_y = H_z = f(x - ct)$ to cover the entire space we lose sight of the [illegible] beam which is our main concern. We get on the other hand a bundle of

[illegible] line $y=l$, $z=k$.

[illegible] x axis by

$$E_y = Ae^{-(\lambda_1^2 y^2+\lambda_2^2 z^2)} \sin k(x-ct)/(x-ct)$$
$$H_z = Ae^{-(\lambda_1^2 y^2+\lambda_2^2 z^2)} \sin k(x-ct)/(x-ct)$$

[illegible] us (putting $\xi = x-ct$),

[illegible]

$$= \frac{A^2}{\pi}\cdot\frac{\pi}{8\lambda_1\lambda_2}\Big[- \text{[illegible]} + \int_0^\infty \text{[illegible]} \Big]$$

[illegible]

Putting $\lambda_1\lambda_2 = 2a^2$, we get the total electromagnetic energy as $W = \frac{1}{2} A^2\mu^2 k$, μ having the dimension of a length.

In the first edition the electric vector was assumed [illegible] the xy plane [illegible] that this is the limiting case [illegible] electric vector is [illegible] xy plane and the magnetic vector [illegible] energy.

[illegible] at any instant is given by

$$\frac{1}{8}\int_{-\infty}^{\infty} E_y^2/8\pi\, dx.$$

[illegible] $\xi = x - ct$)

$$W = [illegible]$$

[illegible]

The factor [illegible] length.

[illegible]

$\pm 2\pi/h$, $\pm 3\pi/h$ ......

[illegible]

[illegible] Maxwell [illegible] Poynting's theorem is modified. An expression may be derived as follows. Consider the energy [illegible]

[illegible] surface [illegible] given by [illegible]. Since x and t [illegible] only in the [illegible]

[illegible]

$$H = \frac{1}{8\pi}\iiint [illegible]\, dx\, dy\, dz \quad \text{where } [illegible]$$

$$[illegible] = -\frac{1}{8\pi}\frac{\partial}{\partial x}\iiint [illegible]$$

$$= -\frac{1}{8\pi}\iiint [illegible] = -\frac{1}{8\pi}\iint [illegible]$$

[illegible]grating along a thin rod parallel to the x-axis, x_2 and x_1 being the x-coordinates of the ends of the rod.

$$= -\frac{1}{8\pi}\int lF\,dS$$

[illegible] the surface, l being the [illegible] cosine of [illegible]

Thus the [illegible] of energy within [illegible] surface [illegible] to the [illegible] flow [illegible] the surface in the direction of the [illegible]. The Poynting vector [illegible] wave

$$S_x = \frac{c}{8\pi}\,\frac{A^2 \sin^2 k\xi}{\xi^2}.$$

Similarly for the magnetic [illegible]

therefore,

$$[illegible]\iiint \frac{\sin^2 k\xi}{\xi^2}\, [illegible] = [illegible]$$

[illegible]
theory,

$$mc^2 = h\nu$$

the impulse

$$mc = h\nu/c.$$

[illegible]

5. It is obvious that the expression

$$\frac{A \sin k\xi}{\xi} = A\int_0^k \cos k\xi\, dk$$

[illegible]

It is extremely significant that the expression which has been derived from the Maxwell equations with an eye on the Relativity considerations alone, should stand for a packet of simple harmonic waves. [illegible]

The integral

$$A\int_0 \cos k\xi\, dk$$

[illegible]

[illegible]

[illegible]

$$E_{y1} = H_{z1} = A \sin k_1\xi/\xi$$

and superpose on it another

$$E_{y2} = H_{z2} = -A \sin k_2\xi/\xi$$

[illegible]
is given by the expression

$$W = \frac{A^2\mu^2}{4\pi}\int_{-\infty}^{\infty} [illegible] \, d\xi$$

[illegible]

where [illegible]

[illegible]

[illegible] energy of the combination

[illegible]

[illegible] obtained as

[illegible]

[illegible] agrees with observation.

[illegible] waves given by

[illegible]

[illegible]

[illegible] explain [illegible] wave properties [illegible] of the wave-length [illegible] extremely mixed up together. The difference is that while the complete photon possesses a finite energy $h\nu$, the partial photon possesses only infinitesimal energy proportional to δk. In experiments involving the energy and momentum [illegible] the photo-electric effect and the energy distribution in the spectrum, it is the complete photons of energy $h\nu$ which preponderate. While in experiments on wave-length the partial photons of small [illegible], complete photons [illegible] [illegible] experiment [illegible]. A partial photon

$$A \int_{k_0} \cos k\xi \, dk$$

[illegible] complete photon

$$A \sin k\xi / \xi$$

[illegible] go through unaffected. [illegible] amount of [illegible] following passage [illegible]

[illegible] first step toward the formulation of such [illegible] [illegible] point of view [illegible] [illegible] must [illegible]

their ultimate reality.

[illegible] Quantum Mechanics [illegible] postulate is easily understandable, because the two entities are distinct.

[illegible]

[illegible] the expression tends to zero.

[illegible] will go on for ever. The expression [illegible] solves the difficulty [illegible]

$\xi \to \infty$.

Again, [illegible] in the train of simple [illegible] waves [illegible] possessing energy proportional to [illegible] the [illegible] This gives a complete mathematical picture of the process followed in producing interference bands, where a beam of light is split up into two halves and made to recombine after one of them has been retarded. [illegible] two portions of the mirror respectively must, therefore, [illegible]

[illegible] Maxwell electromagnetic theory.

Chapter IV

A NEW THEORY OF MATTER

[illegible]

[illegible] is not of importance, but for fixing [illegible] ideas, we conceive [illegible] small angle of elevation from the equa[illegible]

A loxodrome on the sphere is a curve which cuts the [illegible] case is very nearly a right angle. The coils may, therefore be tak[illegible]

[illegible] polar co[illegible] [illegible] $(0, H_\theta, 0)$.

We have to convert the Maxwell equations to the spherical polar coordinates. The components of curl in these coordinates, of a vector u, components u_r, u_θ, u_ϕ are

$$\frac{1}{r\sin\theta}\left\{\frac{\partial}{\partial\theta}(u_\phi \sin\theta) - \frac{\partial}{\partial\phi}(u_\theta)\right\}$$

$$\frac{1}{r\sin\theta}\left\{\frac{\partial u_r}{\partial\phi} - \frac{\partial}{\partial r}(r u_\phi \sin\theta)\right\},$$

$$\frac{1}{r}\left\{\frac{\partial}{\partial r}(r u_\theta) - \frac{\partial u_r}{\partial \theta}\right\}. \quad \ldots \quad (1)$$

(Love, p. 56.)

[illegible]

$$\frac{1}{\varpi}\frac{\partial}{\partial \phi} = -\frac{1}{c}\frac{\partial}{\partial t}; \quad \frac{1}{\varpi}\frac{\partial}{\partial \phi} = \frac{1}{c}\frac{\partial}{\partial t} \quad \ldots \quad (2)$$

$$\frac{1}{\varpi}\frac{\partial E_z}{\partial \phi} = 0; \quad \frac{1}{\varpi}\frac{\partial (\varpi H_z)}{\partial \phi} = 0$$

[illegible] $\varpi\phi$ [illegible] exist.

[illegible] centre in.

[illegible]

$$E = A \sin k(z - ct) \; (z - ct).$$

[illegible]

[illegible] the character of a wave [illegible]

The following quotation from Jeans (1, p. 54) gives an interesting [illegible] of the theory of [illegible] which has a bearing on the present [illegible] proved fact.

[illegible]

[illegible]

the diffraction effect.

[illegible]

the emitted wave.

[illegible]

formulae:—

[illegible]

$$\omega = \frac{8\pi^2 m e^4}{n^3 h^3} \quad \ldots \quad (2$$

The period [illegible]

$$\frac{2\pi}{\omega} = \frac{n^3 h^3}{4\pi^2 m e^4} \quad \ldots$$

and the frequency of the electron in its orbit is [illegible]

(Sommerfeld, p. 706.)

[illegible]

[illegible] to the Balmer formula

[illegible]

1677 B.

[illegible] $\frac{2\pi^2 m e^4}{[illegible]}$.

[illegible]

quantum numbers. So we have

[illegible]

This is Balmer's formula.

[illegible]

[illegible] **On Bohr's theory Einstein's derivation of the red shift has no meaning.** [illegible] to the class of partial photons of energy $h\nu$ and the fall of the [illegible] level to another, is made up by the [illegible] emitted.

[illegible] Bohr's formula [illegible] handy rule of thumb [illegible] determining [illegible] frequency without its illogical [illegible].

[illegible] find the charge [illegible] electron, we have to apply Gauss' theorem that the total normal induction is 4π times the charge [illegible].

$$4\pi e = \int N dS$$

[illegible] regarded as surface density.

Replace the coils of our model by thin strips of breadth δ, so as to cover the entire spherical surface. [illegible] width of the strip. The normal induction [illegible] thus [illegible] δ and the elementary area $a\,ds$. We have, therefore

$$4\pi e = \int N dS \; [illegible]$$

[illegible]

[illegible] **But the main interest of the result lies in the fact that the figure is a constant and independent of** a **which determines the mass of**

the particle. [illegible] proton and the various mesons.

[illegible] under this category.

[illegible]

where p is the momentum. Thus for [illegible] value of p, the sign of E may be either positive or nega[illegible]

"Th[illegible] states give rise to serious difficulties. The acceleration of such an electron due to an ex[illegible]l force is in the opposite [illegible] [illegible]ry electron but [illegible] [illegible] valid.

[illegible] not possible in the Quantum Theory. [illegible]

[illegible]

are the positrons.

[illegible]

[illegible] occupied.

"In a perfect vacuum Maxwell's equation

$$\operatorname{div} \mathcal{E} = 0$$

[illegible] Maxwell's equation

$$\operatorname{div} \mathcal{E} = 4\pi\rho."$$

[illegible] entirely out of the picture.

[illegible]

[illegible] same as for a free electron [illegible]

[illegible] energy states of the hydrogen atom will [illegible] unoccupied and [illegible] will be occupied. If, for a moment, we imagine the Coulomb field switched on adiabatically, a certain number of electron pairs would thus be created, which means that the vacuum could be polarised by an electromagnetic field.

[illegible]

[illegible]

[illegible] momentum $h/2\pi$ ($\sim mca$).

[illegible]

singularity at the centre.

$$A \sin h(y' - ct') \, (y' - ct').$$

frequency becomes

Consider [illegible] an electron moving with velocity v [illegible] the apparent frequencies

[illegible]

The mean frequency is, therefore,

[illegible]

[illegible]

$\nu(1 + v \cos \alpha/c)$, $(1$ [illegible] $\alpha/c)$.

The mean of these two is

$$\nu(1 - v^2 \cos^2 \alpha/c^2)^{\frac{1}{2}}.$$

[illegible]

$$\nu(1 - v^2 \sin^2 \alpha/c^2)^{\frac{1}{2}}.$$

[illegible] the mass from m to $m/(1-v^2/c^2)^{\frac{1}{2}}$ to the same order of approximation.

[illegible] observer.

[illegible] tentatively.

[illegible] different distances from the nucleus.

[illegible]

[illegible]

CHAPTER V

SUMMARY AND CONCLUSIONS

[illegible]

$$F_y = H_z = A \sin k(x - ct)\ (x - ct)$$

[illegible]

regarded as an over-generalisation

[illegible]

[illegible] latter reduces [illegible]

[illegible] The [illegible] proportional to [illegible] of the spectral lines and the [illegible] of [illegible] rather [illegible] the [illegible] periodic motion [illegible] the potential [illegible] By applying the [illegible] found to be constant. The [illegible] and the pressure [illegible] apparent [illegible] velocity.

[illegible] the concept of [illegible] Maxwell equations [illegible] the [illegible] of the photons [illegible] properties [illegible] disproved [illegible] becomes [illegible] experimental results. A physical [illegible] which leads [illegible] assumptions [illegible] that the [illegible] is not [illegible] What [illegible] that the energy [illegible] represented by [illegible]

[illegible] easily follows.

[illegible]

[illegible] of producing interference bands.

[illegible]

here we have been brought face to face with the charge. Only the density of charge has no meaning in our theory of discrete charges. It may also be pointed out that the two divergence equations of Maxwell are rather difficult to interpret when we leave the old classical standpoint of continuous distribution. The theory of charge is only a re-iteration of the Maxwell equation div $E = \rho$. Only this equation is very often lost sight of and the charge treated as if it was a part of the fundamental concept of matter instead of being only a derived property. Moreover, all the fundamental particles, electrons, positrons, neutrons and protons are placed on the same footing, their different masses being due to the different range of frequencies of waves in their composition. The different signs of the charges are explained by the opposite direction of the electric vector. Mesons also fall in line with the scheme, possessing varying masses but possessing, as far as can be ascertained, the same charge. If the theory is correct, pair production is not due to the conservation of the charge, but to the conservation of angular momentum.

3. Another interesting feature of the new theory is that the radiation from an electron when there is a transfer from one energy level to another, comes from the corpus of the electron itself. It will be recalled that the Bohr theory of the spectrum which runs right through the Quantum Mechanical theory of radiation is based on the Newtonian conception of potential energy. But the Relativity theory has introduced a new conception of field of force. According to the latter, in free space, the distance between two neighbouring points in the four dimensional

continuum of space and time is given by the equation

$$\begin{aligned} ds^2 &= c^2dt^2 - dx^2 - dy^2 - dz^2 \\ &= c^2dt^2 - dr^2 - r^2d\theta^2 - r^2\sin^2\theta d\phi^2, \end{aligned}$$

the signs on the right hand side being a matter of convention. It is quite permissible to take the time with the negative sign and the space coordinates with the positive. But if a particle of mass m is introduced at the origin, the metric is altered to

$$ds^2 = -\left(1+\frac{2m}{r}\right)dr^2 - r^2d\theta^2 - r^2\sin^2\theta d\phi^2 + c^2\left(1-\frac{2m}{r}\right)dt^2.$$

The space may be supposed to have been distorted by the introduction of the particle and the gravitational force is only the apparent consequence of this distortion.

That the Relativity theory mixes up the potential and the kinetic energies can easily be seen from the following example: consider the mass of a particle at rest to an observer O. If this observer has a velocity v with reference to another observer O', the mass of the particle to the latter in energy units is $m_0c^2/(1-v^2/c^2)^{\frac{1}{2}} = m_0c^2 + \frac{1}{2}m_0v^2$. The second term represents the kinetic energy of classical mechanics which has been introduced by a change of position of the observer himself.

In fact, the idea of a field of force as a vector field is, strictly speaking, foreign to the basic idea of the Relativity theory, but has to be used for progress and must be regarded as an approximation. The Relativity mathematics, except for the simplest problems, is extremely complicated. As Eddington has remarked, the problem of two bodies remains yet a challenge to the relativistic mathematician in much

the same way as the problem of three bodies to the classical mathematician.

The idea of radiations emanating from the corpus of the electron is, broadly speaking, more in conformity with the Relativity theory than Bohr's idea based on the classical Newtonian potential. It presents again a more satisfactory means of conveyance of excess energy than Fermi's neutrinos.

A tentative explanation may be offered here for the non-absorption of radio waves by matter. The power of absorption of radiation by electrons, on the present theory, depends on the " hunger " of these electrons for the special radiations. If a large number of electrons are lacking in certain waves in their composition, they will readily absorb radiations of that wave length. Thus visible light is readily absorbed by all matter, while metals with a large number of free electrons absorb radiations more freely than non-conductors. Radio waves can penetrate thick walls because these radiations are usually not missing from the composition of the electrons and are thus transmitted without change. **This property, therefore, depends not so much on the amount of energy of the radiations but on the "hunger" of the electrons for those radiations.**

Lastly, Lorentz transformation gives the longitudinal and transverse Doppler effects. This gives, on the basis of our model of the electron, the Relativity variation of mass which has hitherto been regarded as a postulate. There is no theory extant which even attempts at an explanation.

4. Why photons of certain wave lengths should have the tendency to form coils, some stable others unstable,

we have no idea. The reason can only be understood when we have better insight into the interaction between the different parts of the photon and a more complete picture of their structures. There must be a number of knotty points which will have to be settled before the theory can be regarded as fully established. But if it can stand these tests, modern Physics will have been brought down from the clouds to the base but solid earth. If simplicity be one of the tests of truth, we hope it will be agreed that our model of the fundamental particles has greater claim to recognition than the nebulous and intangible abstractions of modern Physics.

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